

Virtual Environments as Constraints on Decision-Making in Agent Models of Human Organizations

Cliff Joslyn *

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Recent developments in software engineering, artificial intelligence, complex systems, and simulation science have placed an increasing emphasis on concepts of autonomous and/or intelligent *agents* as the hallmark of a new paradigm for information systems. Hype has led to the situation where we can identify nearly anything as an agent, from software subroutines and objects, through asynchronous or separately threaded processes, to physically autonomous devices or organisms, and finally including full AI systems. Our concept of a *semiotic agent* distinguishes agents specifically as *decision-making* systems. These have a sufficient freedom over a variety of possible actions to make specific predictions of their actions impossible at the targeted scale of observation. Clearly this class includes AI systems, but leaves out simpler collective automata or state-transition systems typical of Artificial Life.

We have argued [6] from a systems perspective that all interesting emergent behavior in agent systems must arise from considering them as systems in interaction with some form of environment with a sufficiently rich set of properties in and of itself. We thereby further distinguish semiotic agents from pure decision-making algorithms [7], in that they are embedded in (hopefully rich) virtual environments in which they take actions which have consequences for the future of the agents themselves. Thereby, these environmental interactions induce constraints on the freedom of decision-making on the part of the semiotic agents.

In models of organisms, the virtual environment can be decomposed into at least three levels. Recent work has shown that for each of these levels, the constraints introduced can greatly increase system performance and/or robustness:

Virtual Physics: Agents can be embedded in a virtual physical environment, whether simulating aspects of a real environment or a purely synthetic world. Decisions about actions are thereby constrained relative to the properties of these environments [1, 4].

Communication: Agents can coordinate actions and learn about the physical environment through communication. Decisions about actions are thereby constrained by the semiotic systems used to record, transmit, and interpret information [2, 3].

Shared Knowledge: Finally, decisions of agents may be constrained by a shared set of knowledge or beliefs, for example through a common biological evolution or cultural transmission (training or education) [5].

While all three of these aspects are usually not present in all agent models, we argue that they all become necessary when developing agent models of modern human organizations (for

*Distributed Knowledge Systems Team, Computer Research and Applications Group (CIC-3), Mail Stop B265, Los Alamos National Laboratory, Los Alamos, NM 87545, USA, joslyn@lanl.gov, www.c3.lanl.gov/~joslyn, (505) 667-9096.

example, infrastructure management, disaster response, or search and rescue teams). In these systems the semiotic agents are culturally coherent, with a broad base of shared knowledge; agent communication and interaction is mediated by a computer-based information network with a specific set of protocols; and finally agents must take actions in a real physical environment (terrain or an infrastructure network).

References

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